The University of Minnesota
AGRICULTURAL EXTENSION DIVISION
Special Bulletin No. 70

University Farm, St. Paul January, 1923

Published by the University of Minnesota, College of Agriculture, Extension Division, F. W. Peck, Director, and distributed in furtherance of the purposes of the coöperative agricultural extension work provided for in the Act of Congress of May 8, 1914.

DUSTING SEED GRAIN TO PREVENT SMUT

By E. C. Stakman and E. B. Lambert,
Division of Plant Pathology and Botany

SUMMARY

1. Dusting seed wheat with copper carbonate prevents stinking smut.
2. Dusting with copper carbonate is preferable to formaldehyde treatment for the following reasons:
    1. It saves time and labor.
    2. The seed can be treated any time before planting and it is not necessary to use great care in disinfecting seed containers.
    3. The seed does not become wet. Freezing therefore will not injure it, nor is there any danger of heating or sprouting if it is necessary to keep it for some time after treating. The drill does not have to be set for swollen grain.
    4. Copper carbonate dust does not injure the seed as formaldehyde often does.
    5. Copper carbonate dust has a tendency to stimulate seed germination and thus increases yields.
3. In the experiments made during 1921 and 1922, smuts of oats also were controlled by copper carbonate and the average yields of treated plots were greater than those of the untreated plots. It is probable that the dust also will prevent rye smut and covered smut of barley, but more experiments must be made to determine this point.
4. Two ounces of dust will treat one bushel of seed grain.
5. Copper carbonate dust can be purchased from drug stores for about twenty cents per pound. The cost of treating a bushel of seed is about two and a half cents.
6. The dust must be mixed thoroly with the seed. Every kernel should be covered. This can be done best by the use of a simple mixer made like a barrel churn or a cement mixer. (See page 6.)
7. Experiments have been made also with two other chemical dusts: anhydrous copper sulphate plus lime, and Seed-O-San. The copper

sulphate and lime mixture was not so generally satisfactory as copper carbonate. Seed-O-San stimulated seed germination even more than copper carbonate, but it did not entirely prevent smut. Both are used in exactly the same way as copper carbonate.

8. Chlorophol, a new fungicide, which must be used in solution, prevented smut and did not injure the seed in any of the tests.
9. Smuts of oats and covered smut of wheat can be practically controlled by copper carbonate dust.
10. The dust also may control the covered smut of barley, flag smut of rye, kernel smut of sorghum, and millet smuts. Experiments are being made to determine this.
11. **The loose or naked smuts of wheat and barley, timothy smut, corn smut and the head smuts of sorghum and timothy are not prevented by chemical dusts. Neither are they prevented by the ordinary formaldehyde treatment. Methods for controlling them will be found in Minnesota Special Bulletin No. 16.**
12. **See your county agent regarding methods and materials.**

WHAT THE NEW TREATMENTS ARE

Chemical Dusts

Within the last few years it has been found that copper carbonate applied to the seed as a dust will prevent smuts. In addition to copper carbonate, powdered copper sulphate (bluestone) and lime mixture, and Seed-O-San (a patented compound) have given good results.

The copper carbonate has been tried extensively and can be recommended highly. The Seed-O-San and powdered copper sulphate were less satisfactory. All three of these substances are chemical dusts. They are dusted on the seed grain. No water is used in making the treatment.

Liquids

Several proprietory fungicides which must be dissolved in water before being used also have been developed during the last few years. Chlorophol, which was the one most extensively tested, effectively controlled smut without injuring the seed.

ADVANTAGES OF THE NEW TREATMENTS

The advantages of treating grain seed with dusts rather than with liquid solutions are quite obvious. The dusts can be applied easily, it is usually not such an unpleasant job to handle them as it is to handle solutions, and the work can be done quickly. The principal advantage of the dusts over formaldehyde, however, is that they do not injure the treated seed.

In Minnesota, formaldehyde has been almost exclusively used for the prevention of smuts. It prevents smuts very effectively. However, under some conditions, the treated seed is quite severely injured. The injury is especially likely to result when the treated grain is dried rather quickly. If the treated seed is sown while still wet, the injury is greatly reduced. However, it is not always possible to do this, and even if grain is sown while still moist, it is likely to be injured if sown in dry soil. The farmer can not control the amount of soil moisture, neither can he afford to wait until the soil becomes moist. Therefore, even when following the best methods of treating with formaldehyde, some seed injury is likely to occur. If the treated seed is frozen while still moist, the percentage of germination is likely to be reduced. Furthermore, if the grain can not be dried when it is necessary to keep it for some time after treatment, it may heat or sprout during periods of moist, rainy weather. For these reasons, grain treated with formaldehyde often actually yields less than untreated grain.

The dust treatments of course avoid wetting the grain, consequently there is no danger of freezing or heating. Furthermore, the grain can be treated at any time before sowing, even during the cold weather in the winter. This saves considerable labor and time during the busy sowing season. The chemical dusts do not reduce the germination of the seed, but on the contrary are likely to cause the treated seed to germinate quickly and vigorously and thus increase yields. The test plots treated with copper carbonate or Seed-O-San yielded more, on the average, than the untreated plots or those treated with formaldehyde. Further work must be done, but the stimulatory effect of these substances sometimes was so great as to suggest that it might be worth while even to treat smut-free seed in order to increase yields.

The copper carbonate and the copper sulphate plus lime mixture practically eliminate smut. Seed-O-San is less effective as a fungicide. It is possible that the liquids, formaldehyde and chlorophol, might be slightly more effective on very heavily smutted seed lots, but the chemical dusts practically eliminate smut from any seed that is clean enough to be used.

Seed lots of wheat usually are not very badly smutted in Minnesota because Marquis, the most commonly grown variety, is moderately resistant to bunt or stinking smut. It is quite unlikely therefore that seed lots of Marquis would ever be so severely smutted as to make the chemical dust treatments ineffective. Preston, Haynes Bluestem, Glyndon Fife, and Kota, however, are much more susceptible, and the extensive sowing of them, untreated, is certain to increase covered smut.

While formaldehyde sometimes is somewhat more effective against oat smut than are the dusts, its tendency to injure the seed offsets this

advantage, and it seems much more advisable therefore to treat with dusts. The covered smut of barley and the flag smut of rye are both controlled by surface disinfection of the seed and the dusts may therefore control them. Further evidence is necessary, however, before the treatment of barley and rye can be definitely recommended.

The cost of treating with copper carbonate dust is about two and a half or three cents a bushel. This is very little more than the cost of treating with formaldehyde. The cost of powdered bluestone should be about the same. The cost of Seed-O-San is not known.

Since, therefore, the chemical dusts are fairly cheap, practically eliminate smut from the seed lots, are easy to apply, can be applied at any time before sowing, do not wet the seed, do not injure the seed, but on the contrary usually stimulate germination, they are much more desirable than the old wet treatments with either formaldehyde or bluestone solution. Furthermore, the dusts are very likely to increase yields on account of causing a more rapid, uniform, and vigorous germination of the seed.

SMUTS PREVENTED BY DUSTS

The common smuts which are prevented by the ordinary formaldehyde treatment also may be controlled by dusts. Definite experiments have been made on the control of bunt or stinking smut of wheat and the smuts of oats at the Minnesota Experiment Station and elsewhere, and the dusts were effective against them. It is probable also that the dusts may prevent covered smut of barley, flag smut of rye, kernel smut of sorghum, and millet smuts. However, this is not yet definitely known. On account of the smoothness of the sorghum and millet seeds, it is possible that the dust will not stick to the surfaces well enough to be effective.

The loose or naked smuts of wheat and barley, timothy smut, corn smut, and the head smut of sorghum are not prevented by chemical dusts. Neither are they prevented by the ordinary formaldehyde treatment. Methods for controlling them will be found in Minnesota Special Bulletin No. 16.

AVAILABILITY OF MATERIALS

Copper Carbonate

It should be possible to obtain copper carbonate dust from almost any drug store. It probably can be obtained in quantity also from any wholesale drug company. The material used in the experiments was obtained from the Corona Chemical Division of the Pittsburgh Plate Glass Company, of Milwaukee. It contains about twenty per cent of available copper. It is light and fluffy, which increases its spreading

power on the seed. The Corona product is better than heavier material which does not spread so well. The Corona Company has furnished much of the material to local druggists.

Powdered Copper Sulphate and Lime

The powdered anhydrous copper sulphate and lime can be obtained from drug stores. These dusts must be thoroly mixed and dried before using. The mixture is not recommended as highly as copper carbonate, since it has a tendency to take up water and become lumpy.

Seed-O-San

Seed-O-San is manufactured by the Standard Tester Company, of Chicago. As far as the writers have been able to determine, it has not yet been put on the market. Its chief value lies in its ability to stimulate the seed, since it does not control smut as well as the other dusts.

Chlorophol

Chlorophol may be obtained from the same company as Seed-O-San. Its chief value lies in its ability to control smut.

COST OF MATERIALS

Copper carbonate probably can be purchased for approximately twenty cents per pound. The price varies in different localities. Since only two ounces are needed to treat a bushel of seed, the cost is approximately the same as that of formaldehyde. It should not exceed two and a half or three cents per bushel. The cost of the ground copper sulphate and lime also should be approximately the same as that of formaldehyde.

METHODS OF APPLYING DUST

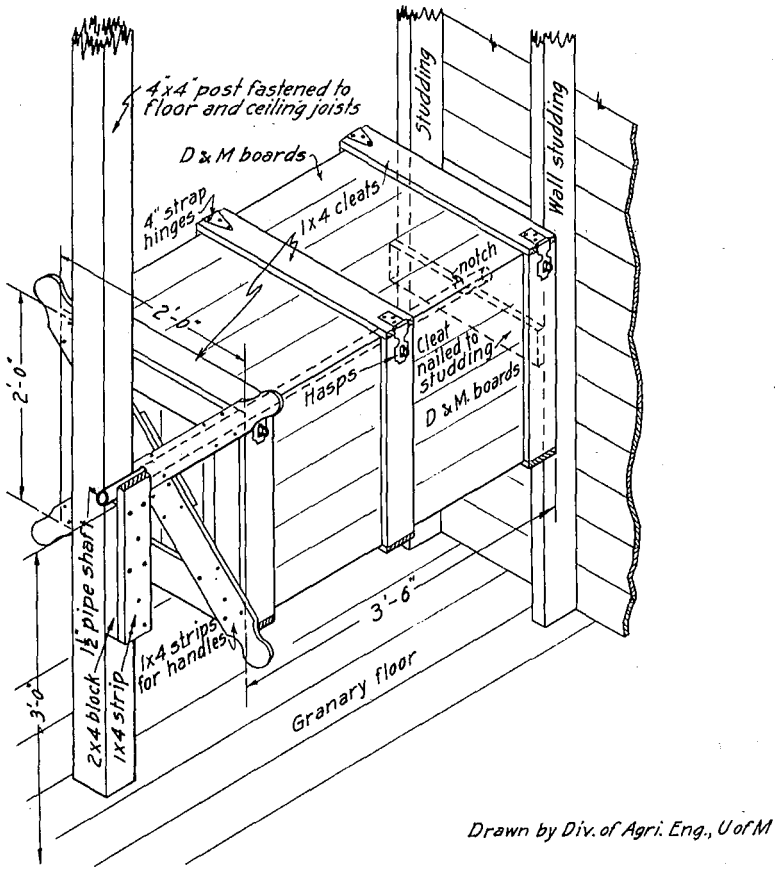
Amounts Used

From two to four ounces of copper carbonate, copper sulphate and lime, or Seed-O-San will treat one bushel of grain. It has been found by experiment that even more can be used without any danger of injuring the seed. The effectiveness of the treatment depends very largely on the thoroughness with which the dust covers the kernels. If a barrel churn, a cement mixer, or a special device such as is described on page 6 is used, two ounces are enough. If the shoveling method is used, it would be better to use four ounces. The writers have applied as much as ten ounces per bushel and the seed germinated normally. Note:

Chlorophol is used in a solution of four and a half ounces to twelve gallons of water. Two and a half bushels of grain are stirred into the solution and allowed to stand for one hour. The seed is then dried and stored in *clean containers*. Only two lots of seed may be treated in the same solution, and metal containers should not be used.

Methods of Mixing With Seed

Good dusting means covering all the kernels thoroly with the dust. The simplest method is to add the dust to a pile of grain containing the proper number of bushels, and then shovel over thoroly. However, this method is quite objectionable because the workers are likely to breathe a considerable amount of the dust, and it is difficult to mix the dust and seed thoroly. A much more satisfactory method is to place the proper amount of grain in a barrel churn or some similar contrivance, add the proper amount of dust, then rotate the churn vigorously for a minute or two.



A piece of metal pipe is run through a tight box. One end of the pipe rests in a notch in a cleat which can be nailed across two wall studdings of the granary. The other end rests on a cleat attached to a post fastened to the floor and ceiling joist. The box can be rotated by means of the cross strips indicated.

Eventually, special dusting machines will be used almost entirely. A satisfactory machine is a tight box or hollow drum with a closely fitting door mounted in such a way as to make it possible to rotate it like a barrel churn. A cement mixer should also be satisfactory.

A suggested machine that can easily be made is shown in the figure. Another type could be made like a barrel churn, rotated by means of a sprocket and chain.

The dust should not be inhaled. If a specially constructed treater is used there will be very little likelihood of any discomfort from breathing the dust. It would be well, however, to tie a cloth over the nose and mouth or to use a specially made respirator. The dust is sometimes rather unpleasant. It is advisable always to stand on the windward side.

When to Treat

One of the great advantages of treating with dusts is that the grain can be treated at any time before it is sown. It can be treated just as well during the winter as later in the season. Since the grain does not become wet, there is no danger of freezing. It has been found that the dust retains its effectiveness on the seed even when applied six months before the seed is sown.

RESULTS OBTAINED WITH DUST TREATMENTS

Results Obtained Outside of Minnesota

The dust treatments were first used in Australia. Darnell Smith (1, 2) first began to use copper carbonate because formaldehyde injured the seed very severely in Australia on account of the dryness of the soil. Copper sulphate was used more commonly in Australia than formaldehyde, but it also injured the seed under certain conditions, and the method of treating was rather cumbersome. In the United States, Mackie and Briggs (3) in California first made extensive experiments with the dust treatments. The results were so satisfactory that copper carbonate is now being recommended in California. Heald and others also made extensive tests on both spring and winter wheats in Washington state. These results also were excellent. In a recent bulletin Heald and Smith (4) recommend the use of copper carbonate dust for the control of bunt or stinking smut of wheat. Coons (5) also tried the effect of copper carbonate on wheat in Michigan, and concluded that stinking smut could be controlled effectively. The copper carbonate as well as other chemical dusts, has been tried quite extensively in Germany. In some years the results have been very satisfactory, while in other years, especially when the seed lots were very severely smutted, the copper carbonate did not eliminate the smut entirely. The writers are convinced, however, that these dusts eliminate smut in any seed lot which is not so badly smutted as to unfit it for seed purposes under any circumstances.

Results in Minnesota

Experiments were made in Minnesota on wheat, oats, barley, and rye during 1921 and 1922, and the results of treating with copper carbonate have been uniformly good. The effect on smut was determined and yield tests also were made. These experiments were conducted at University Farm, Waseca, Morris, Crookston, Grand Rapids, and Duluth.

Experiments in 1921

The experiments in 1921 were all made at University Farm. (6) The effect of various fungicides on the germination of wheat, oats, barley, and rye was determined by laboratory experiments. Field experiments were made to ascertain the effect of the fungicides on smut and on yield. The results are given in Tables I, II, and III.

Table I. Effect of Formaldehyde and Copper Carbonate Dust on the Germination of Wheat, Barley, Rye, and Oats in Moist, Sandy Loam

Kind of grain	Treatment and percentage of germination (average of three tests)			
	Formaldehyde sprinkle	Formaldehyde spray	Copper carbonate dust	No treatment
Marquis wheat	70	58	80	63
Iowa 108 oats.....	92	83	92	95
Manchuria barley	96	96	96	97
Spring rye	63	23	74	60

Table II. Comparative Effect of Four Chemical Dusts on Percentage of Germination of Wheat, Oats, Barley and Rye in Moist Sandy Loam

Treatment	Percentage of germination							
	Wheat		Oats		Barley		Rye	
	Replicated tests	Average	Replicated tests	Average	Replicated tests	Average	Replicated tests	Average
Seed-O-San	92		96		95		84	
	93	91	98	93	98	97	85	87
	87		88		98		92	
Mackie's dust	57		100		86		78	
	65	59	98	99	92	91	76	79
	55		100		94		82	
Copper carbonate, 52 per cent Cu. equivalent	62		92		95		77	
	56	59	90	92	98	96	79	77
	58		94		95		75	
Copper carbonate, 20 per cent Cu. equivalent	53		98		98		79	
	72	63	98	99	94	96	82	78
	65		100		95		73	
Check	68		96		96		86	
	61	62	97	97	97	95	78	81
	58		97		93		78	

Table III. Effect of Formaldehyde and Copper Carbonate on Amount of Stinking Smut in Wheat and on Yield

Treatment	Germination*	Yield per acre	Smutted heads
	Per cent	Bushels	Per cent
Treated with (50:50) formaldehyde immediately before planting..... Smut balls not fanned out	44	11.0	3.0
Treated with (50:50) formaldehyde immediately before planting..... Smut balls fanned out	53	13.3	0.0
Treated with (50:50) formaldehyde three weeks before planting..... Smut balls not fanned out	23	3.3	3.5
Treated with (50:50) formaldehyde three weeks before planting..... Smut balls fanned out	26	0.0	0.0
Treated with (1:320) formaldehyde immediately before planting..... Smut balls not fanned out	58	7.0	0.0
Treated with (1:320) formaldehyde three weeks before planting..... Smut balls fanned out	44	10 0	1.0
Treated with (1:320) formaldehyde immediately before planting..... Smut balls not fanned out	52	12.3	0.4
Treated with (1:320) formaldehyde three weeks before planting..... Smut balls fanned out	65	10.0	0.0
Treated with 4 oz. copper carbonate dust per bushel..... Smut balls not fanned out	70	19.3	0.0
Treated with 4 oz. copper carbonate dust per bushel..... Smut balls fanned out	72	20.0	0.0
Treated with 2 oz. copper carbonate dust per bushel..... Smut balls fanned out	78	14.6	0.0
Washed in water immediately before planting ..... Smut balls fanned out	0	14.6	4.0
No treatment ..... Smut balls not fanned out	0	14 6	21.0
No treatment ..... Smut balls fanned out	86	15.3	16 0

* Germination tests were made on blotting paper.

It will be seen from Table I, which is typical of the results obtained in a number of tests, that the wheat and rye seed treated with copper carbonate dust germinated best. The formaldehyde spray killed many seeds of wheat and rye and also considerably reduced the percentage of germination of oats. Barley was not injured. Sprinkling with formaldehyde did not cause any appreciable injury under the conditions of the experiment. In fact, the treated seed of wheat and spring rye actually germinated better than untreated seed.

The effect of four chemical dusts on seed germination of wheat, oats, barley, and rye is given in Table II.

It is clear from Table II that the percentage of germination of wheat and rye seed varies more than that of oats and barley. Since wheat and rye are likely to be injured more by formaldehyde, it is probable that this is due to the protection of the hull on oats and barley seed.

Seed-O-San stimulated wheat seed greatly, especially in moist soil. The seeds germinated more uniformly, the stand was more uniform, and the seedlings were an inch higher than those from untreated seed.

The effect of formaldehyde on the percentage of smut of oats and stinking smut of wheat was also tried in the field at University Farm. The results are given in Tables III and IV. It is clear from Table III that the copper carbonate dust prevented smut. No reliable conclusions, however, can be drawn from the yield data since the tests were of a preliminary nature and not sufficiently replicated.

Table IV. Effect of Formaldehyde and Copper Carbonate on Amount of Smut and Yield of Oats

Treatment	Germination*	Yield per acre	Smut
	Per cent	Bushels	Per cent
Treated with (50:50) formaldehyde immediately before planting.....	95	92.9	3
Treated with (1:320) formaldehyde immediately before planting.....	93	91.7	0.2
Treated with copper carbonate dust immediately before planting.....	89	85.8	0
No treatment	98	64.6	13

* Germination tests were made on blotting paper.

Experiments in 1922

In 1922 wheat, oats, and barley were treated and sown at University Farm, St. Paul, and at the substations. The results are given in Tables V, VI, and VII.

From Table V it is clear that copper carbonate dust controlled smut fairly well. The average yield of the treated plots was about three bushels per acre more than that of the formaldehyde plots and about a bushel more than that of the untreated plots. Treating with formalde-

hyde resulted in a decreased yield at St. Paul, Crookston, and Waseca. At Grand Rapids, where there was the most smut, the seed treated with formaldehyde yielded best.[1]

V. Results of Treating Wheat with Various Fungicides

Station	Formaldehyde		Chlorophol		Seed-O-San		Copper carbonate		Check	
	Yield p r acre	Per cent smut	Yield per acre	Per cent smut	Yield per acre	Per cent smut	Yield per acre	Per cent smut	Yield per acre	Per cent smut
	Bu.		Bu.		Bu.		Bu.		Bu.	
Morris	14.9	0	16.0	0	17.4	2.6	18.1	0.0	15.3	2.0
Crookston	17.4	0	22.6	0	23.7	0.6	22.2	1.6	20.6	11.3
Grand Rapids..	23.0	0	22.1	0	22.3	1.0	22.3	0.3	21.5	8.3
St. Paul	20.9	0	27.5	0	27.8	0.0	28.5	0.0	26.3	0.6
Waseca	18.8	0	21.6	0	30.1	1.5	19.5	0.0	22.5	6.5
Average ...	19.0	0	21.9	0	24.2	1.1	22.1	0.2	21.2	3.1

Table VI. Results of Treating Oats with Various Fungicides

Station	Formaldehyde		Chlorophol		Seed-O-San		Copper carbonate		Check	
	Yield p r acre	Per cent smut	Yield per acre	Per cent smut	Yield per acre	Per cent smut	Yield per acre	Per cent smut	Yield per acre	Per cent smut
	Bu.		Bu.		Bu.		Bu.		Bu.	
St. Paul	48.4	0	57.9	0	63.8	*	51.1	0	55.5	1.0
Crookston	69.1	0	79.5	0	72.6	*	81.3	*	77.0	*
Duluth	38.5	*	49.5	*	62.8	1	55.5	*	46.1	1.6
Waseca	55.1	0	54.9	*	53.5	*	52.6	*	55.1	2.5
Average ...	52.7		60.4		63.1		60.1		58.6	1.2

* Indicates less than one per cent smut.

The data in Table VI indicate that a slight increase in the average yield of oats, sown in four localities, resulted also from the use of all the various fungicides except formaldehyde, which again seemed to reduce the average yield.

[1] The extensive tests carried on in 1922 were made possible by the co-operation of the substations. Not all the stations, however, were able to plant the complete series of wheat, barley, and oats. At Morris wheat and barley were sown, at Grand Rapids wheat only, at Duluth oats only, and at Crookston, Waseca, and St. Paul the entire series. The wheat used at Grand Rapids was a smutty sample of Prelude, while that used at all other stations was a soft smutty sample obtained from Fort William, Canada. This lot was a mixture of several different varieties, but Marquis predominated. The barley and oats seed were obtained locally by each co-operating station. Yield results from Waseca were calculated on a basis of only two one-fortieth acre plots. The yield results tabulated for all stations except St. Paul, represent the averages of three systematically replicated fortieth-acre plots. At University Farm, the yields are the average of four rod-row plots.

The average percentage of smut was reduced by the fungicides in the same order as for wheat. There was, however, very little smut in the check plots.

Table VII. Results of Treating Barley with Various Fungicides

Station	Formaldehyde		Chlorophol		Seed-O-San		Copper carbonate		Check	
	Yield per acre	Per cent smut	Yield per acre	Per cent smut	Yield per acre	Per cent smut	Yield per acre	Per cent smut	Yield per acre	Per cent smut
	Bu.		Bu.		Bu.		Bu.		Bu.	
Waseca	51.5	0	48.6	0	51.2	0.0	52.0	0.0	50.0	0.0
Morris	44.4	0	48.4	0	43.0	0.0	41.2	0.0	38.1	0.0
St. Paul	65.3	0	63.1	0	60.0	0.0	60.8	0.0	61.2	0.0
Crookston	62.6	0	55.9	*	46.8	0.6	62.3	0.6	48.6	1.3
Average ...	55.9		54.0		50.2		54.1		49.4	

* Indicates less than one per cent smut.

The average barley yields (see Table VII) were greater in all the plots sown to treated grain. The highest average yield was obtained from plots sown with barley treated with formaldehyde. There was not enough covered smut in any of the plots to justify drawing conclusions.

LITERATURE CITED

1. Darnell-Smith, G. P. The Prevention of Bunt. Agr. Gaz. New South Wales 28: 185-189. 1917.

2. ———————— and Ross, H. A Dry Method of Treating Seed Wheat for Bunt. Agr. Gaz. New South Wales 30: 685-692. 1919.

3. Mackie, W. W. and Briggs, F. N. Fungicidal Dusts for the Control of Smut. Science N.S. 52: 540-541. Chemical Dust for the Control of Bunt. Phytopath. 11: 38-39. 1921.

4. Heald, F. D. and Smith, L. J. The Dusting of Wheat for Bunt or Stinking Smut. Wash. Agr. Exp. Sta. Bul. 171, pp. 3-27. 1922.

5. Coons, G. H. A New Method for Stinking Smut Control. Mich. Agr. College, Quarterly Bul. 5: 8-11. 1922.

6. Lambert, E. B. and Bailey, D. L. Results of Treating Seed of Spring Wheat and Oats with Copper Carbonate Dust to Prevent Smut. Phytopath. 12:36. 1922.